DOE/Nuclear Physics Review
RHIC Science and Technology
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Experiment Operations and Mid-Term Plan Status

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U.S. DEPARTMENT OF ENERGY

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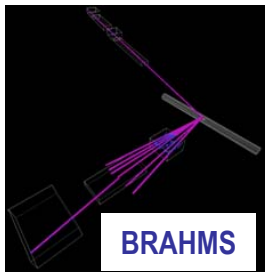
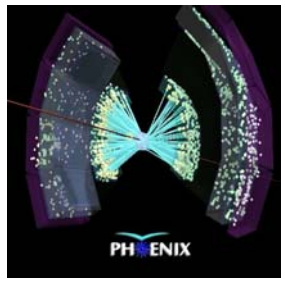
U.S. Department of Energy

Evolution of the Experimental Program

The Initial Suite of Detectors… BRAHMS, PHENIX, PHOBOS, STAR





- **Quark Matter Properties in Heavy Ion collisions**
  - Collective, hydrodynamic motion: "perfect liquid", strong coupling
  - Partonic energy loss
  - Gluon saturation
  - Established the efficacy of auto-generated "hard probes"

- **Spin Program: p-p at $\sqrt{s}$ = 200 GeV**
  - A_{LL} in 200 GeV p-p: ΔG small, in measured range
  - Emergence of transverse spin physics
  - Polarimetry established at 5% level

The Next Phase

Four Detectors ⟶ Two Upgraded Detectors

Measurements for RHIC II Science goals & Performance Milestones

- **Precision measurements in Heavy Ion collisions**
  - Heavy Flavor; γ - jet; quarkonia; multiparticle correlations
- **500 GeV Spin program**
  - W production in 500 GeV p-p

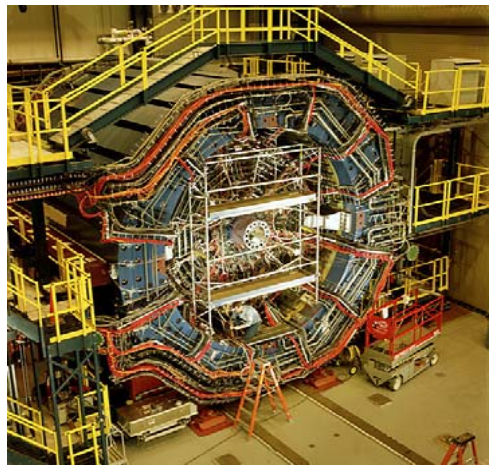
Luminosity Growth:

Average store luminosity, $cm^{-2}sec^{-1}$

	2004	2007/2008	2012
Au-Au	$5x10^{26}$	$12x10^{26}$	$46x10^{26}$
p-p	$4x10^{30}$	$20x10^{30}$	$103x10^{30}$

Evolution of the Experimental Program - II

Detector Suite: Upgraded PHENIX and STAR



Necessary detector upgrades:

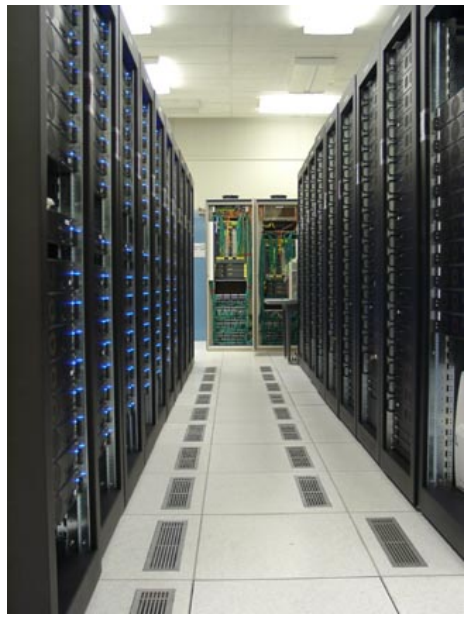
- **High data-rate capability:** STAR & PHENIX DAQ upgrades
- **Hadron and Photon particle ID:** STAR TOF; PHENIX NCC
  [PHENIX Hadron Blind Detector; STAR Forward Meson Spectrometer]
- **Precision vertex detectors:** Open Charm and Beauty
  PHENIX VTX, FVTX; STAR HFT
- **Forward detectors:** $W^{\pm}$ in 500 GeV p-p
  PHENIX Muon Trigger; STAR FGT

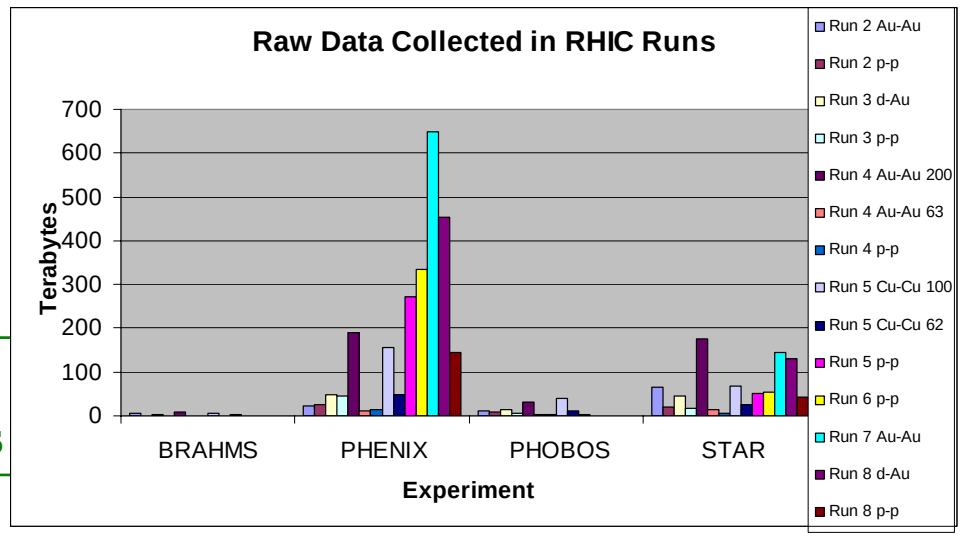
RHIC Computing Facility...

Data Transfer and processing from all four experiments.

FY 2008 capacity

- Mass Storage System:
  - 5 StorageTek robotic tape silos **~15 PBytes**
  - 67 tape drives **~ 3.6 GB/Sec**
- CPU:
  - 4900 CPU Intel/Linux processor farm
    ~8100 kSPECint2000 (~12 Tflops)
- Central Disk:
  - 320 Tbytes RAID 5 storage
  - 4.3 Gbyte/sec disk I/O capacity
  - 2000 Tbytes distributed disk



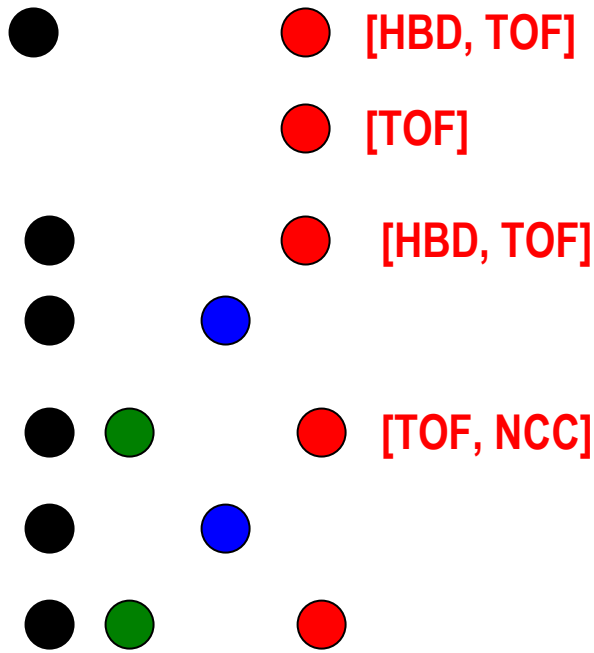


Initial investment: ~$8M (FY 2000$)
Annual equip. funds of ~$2M for upgrades

2008 PAC Run Plan Recommendations: upgrades needed

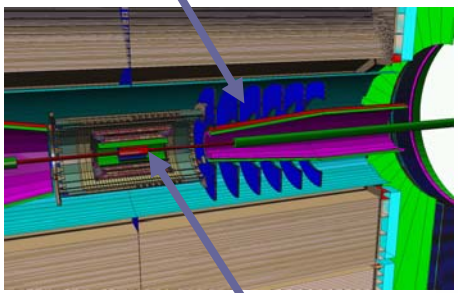
DAQ Vertex Forward Detectors Particle ID

Fiscal Year	Colliding Beam Species/Energy	Comments
2009	200 GeV p+p	A_{LL} measurements
2010	500 GeV p+p	Commissioning
	200 GeV Au+Au	9-10 physics weeks with PHENIX HBD, STAR DAQ1000 & TOF. 1st collision test of transverse stochastic cooling .
2011	Au+Au at assorted low E	Critical point scan.
	200 GeV U+U	1st U+U run with EBIS, to increase energy density coverage
2012	500 GeV p+p	1st long 500 GeV p+p run. Substantial statistics on W production and ΔG measurements
	200 GeV Au+Au	Long production run with full stochastic cooling.
2013	500 GeV p+p	Reach ~300 pb^{-1} to address 2013 DOE performance milestone on W production and sea antiquark polarizations
	200 GeV Au+Au or 2nd low-E scan	To be determined by results of previous runs.



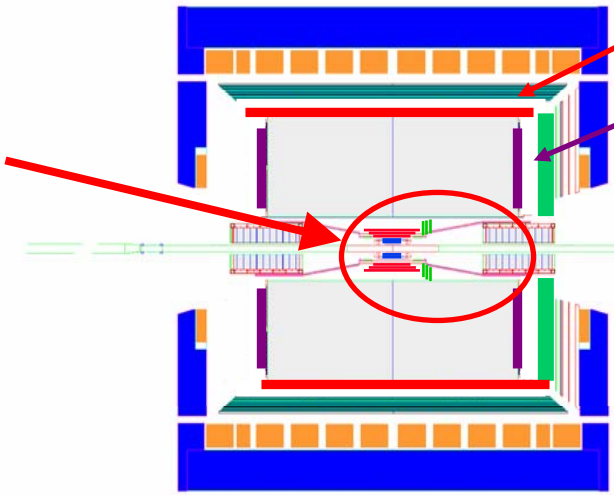
RHIC Detector Upgrades

Forward GEM Tracker



Heavy Flavor Tracker

STAR Detector



TOF Barrel

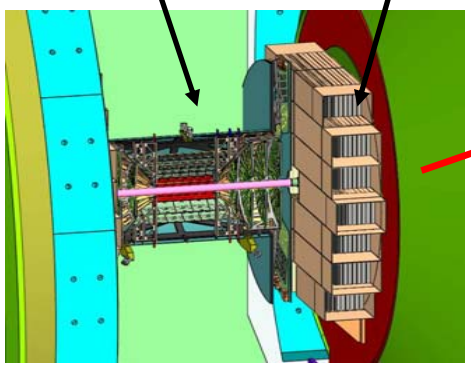
TPC readout: DAQ 1000

Forward Meson Spectr.

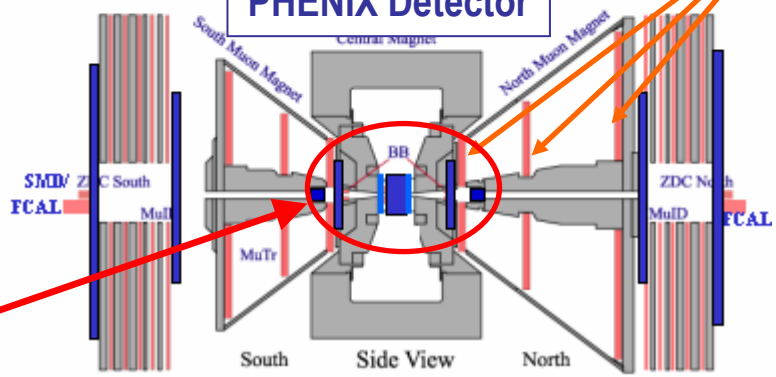
Muon Trigger Stations

Vertex Trackers
VTX, FVTX

Nose Cone Cal.



PHENIX Detector



Hadron Blind Detector

PHENIX and STAR Upgrade Suite:
Several small projects… Individually managed

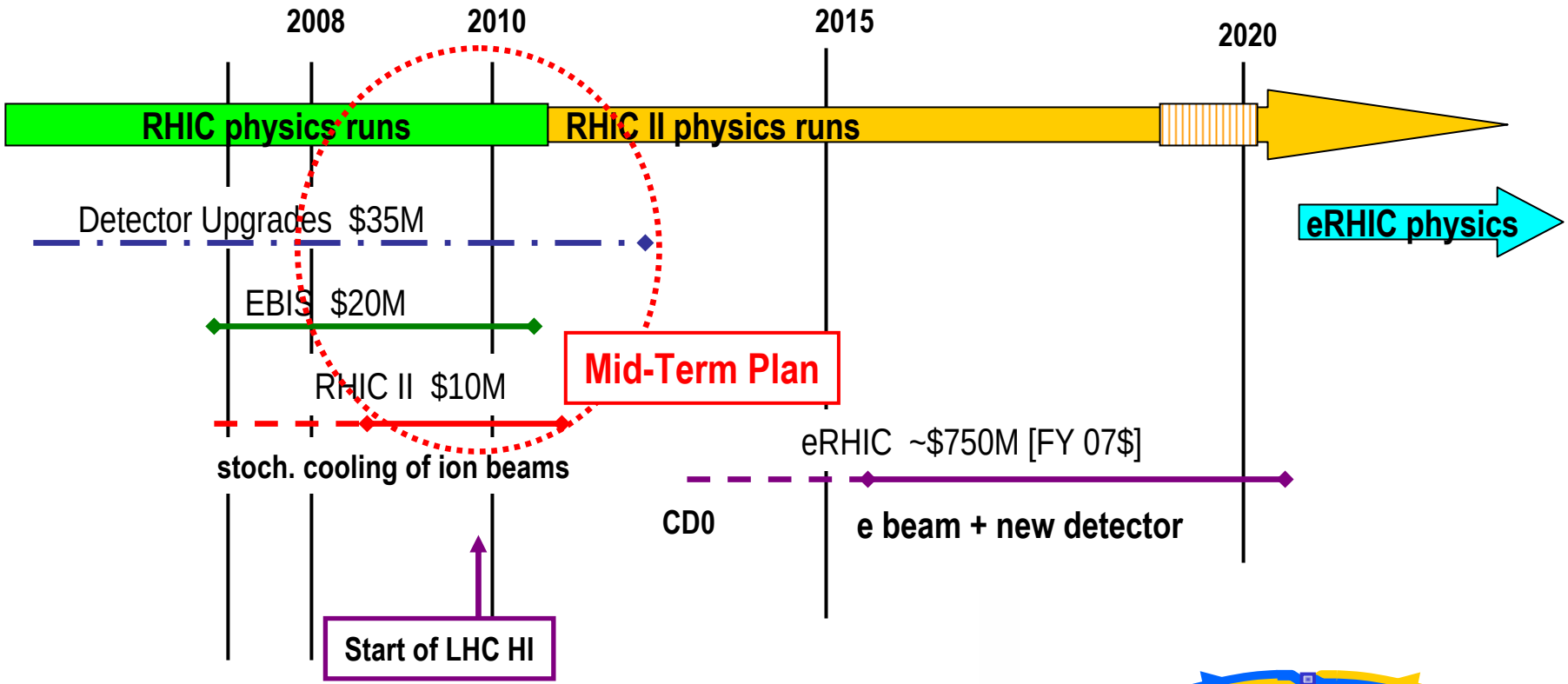
	PHENIX	STAR
Completed:	Hadron Blind Detector	Forward Meson Spect.
On-going:	Muon Trigger Si Vertex (VTX, FVTX)	DAQ 1000 Time of Flight Barrel (TOF) Forward GEM Tracker (FGT)
In preparation:	Forward (Nosecone) Cal (NCC)	Heavy Flavor Tracker (HFT)

Costs:

DOE MIE Projects	$32M
RHIC base	$6M
NSF	$2.2M
In-kind and non-US	$9.5M

~same scale as BRAHMS + PHOBOS

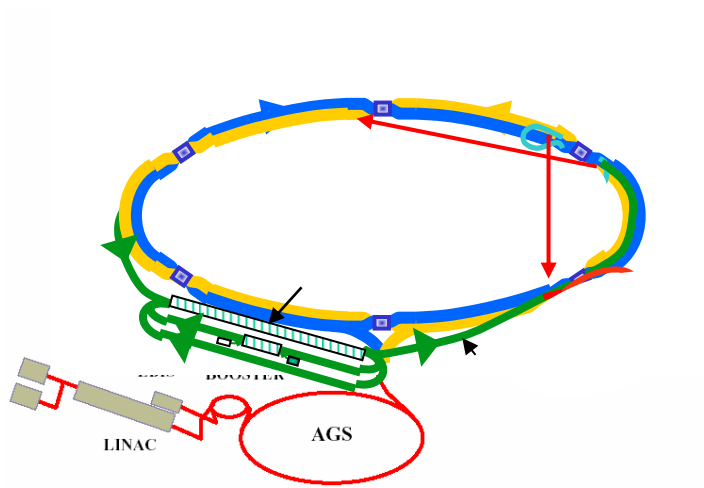
A Long Term (Evolving) Strategic View for RHIC



Legend:

- ***R&D***
- ***Construction***
- ***Multiple small projects***

CD0: DOE Critical Decision, mission need



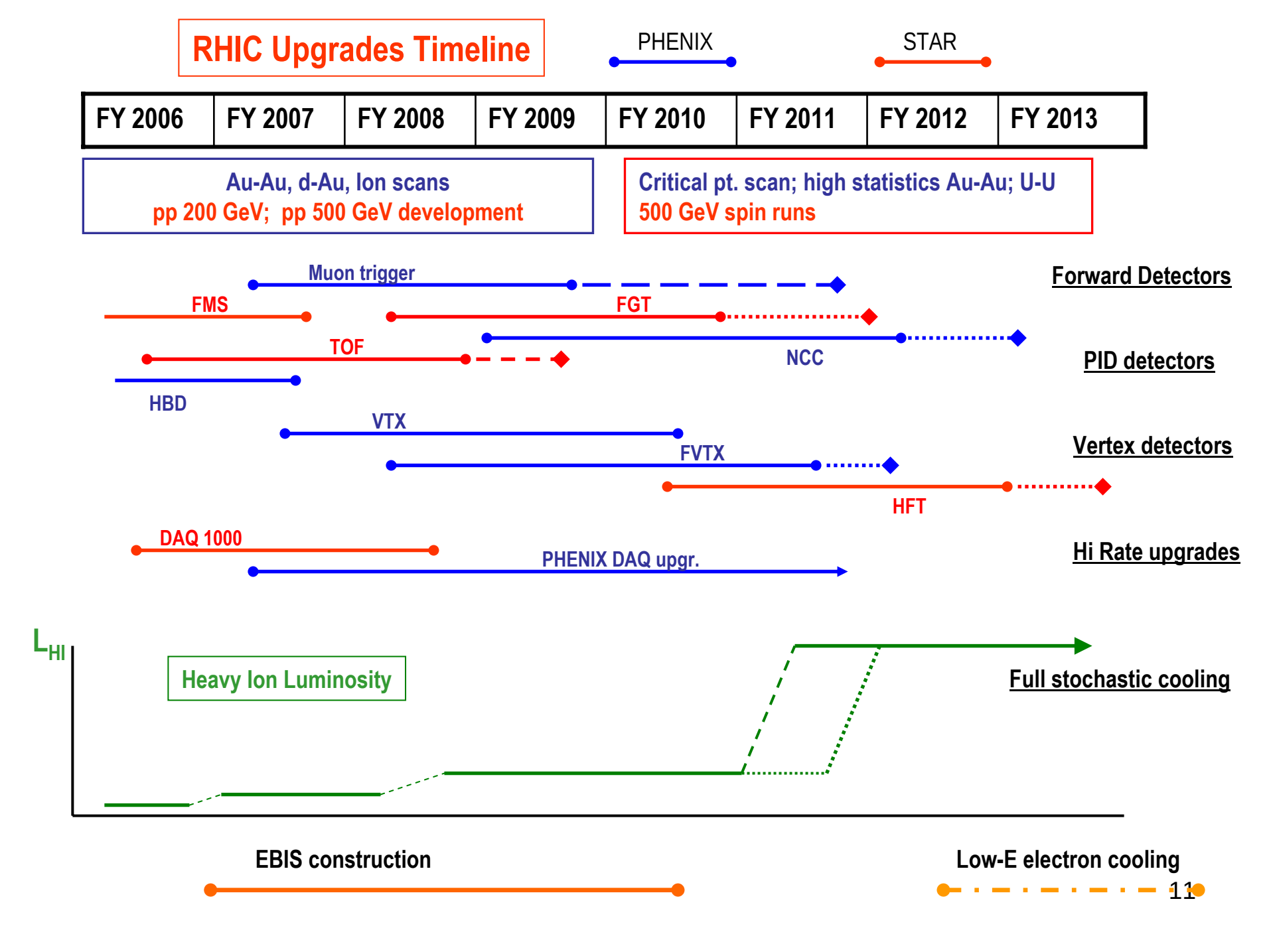
Mid-Term Plan

Current funding plan for detector upgrades

Feb. 08 update: 06 as spent; 07 as spent; 08 approp.; 09P

	FY 2006A	FY 2007A	FY 2008A	FY 2009P	FY 2010	FY 2011	FY 2012	FY 2013	
R&D funds									
PHENIX HBD	0.10								**0.10**
PHENIX MIEs	0.30	0.45	0.16						**0.91**
PHENIX DAQ	0.10	0.05	0.26	0.40	0.40	0.20	0.25		**1.66**
STAR Tracking	0.50	0.32	0.70	0.80	0.40	0.20	0.25		**3.17**
Generic Det. R&D	0.00		0.00		0.40	0.80	1.00	1.50	**3.70**
Total R&D	1.00	0.82	1.12	1.20	1.20	1.20	1.50	1.50	**9.54**
Exp. Capital									
PHENIX HBD/TOFW	0.40	0.10							**0.50**
STAR FMS	0.20	0.20							**0.40**
STAR DAQ1000	0.90	0.35	0.65	0.00					**1.90**
STAR FGT			0.20	0.75	1.00	0.00			**1.95**
Exp. Infrastr.	0.60	0.35	0.45	0.75	1.10	1.00	0.85	0.85	**5.95**
RCF	1.30	1.70	1.70	2.00	2.50	3.00	3.00	3.00	**18.20**
Total Capital	3.40	2.70	3.00	3.50	4.60	4.00	3.85	3.85	**28.90**
MIEs									
STAR TOF	2.40	2.40							**4.80**
PHENIX VTX		1.60	2.00	1.10					**4.70**
PHENIX FVTX			0.50	2.40	1.95				**4.85**
PHENIX NCC			0.20	1.20	2.10	1.00			**4.50**
STAR HFT					2.50	5.50	5.00		**13.00**
Total MIE	2.40	4.00	2.70	4.70	6.55	6.50	5.00		**31.85**

RHIC Upgrades Timeline



Some issues….

STAR TOF: Early technical/cost/schedule problems with electronics vendor–
Resolved: BNL/STAR Steering Committee

PHENIX HBD: Technical problems in 2007 engineering run – Resolved? PHENIX task force

PHENIX Muon Trigger: Cost and schedule issues –
BNL Technical/cost/schedule review in August

PHENIX VTX: Technical issue/possible schedule delay–
Technical and management issues under study: PHENIX, BNL, DOE

Another potential issue… RHIC Computing Facility

Capital Equip. funds for RCF have been below planned levels
Not all investments scale with data volume: e.g. disk replacement; network switches

Impact of upgraded detectors and luminosity on data volume

Non-RCF resources for data analysis: Adequate for future needs?

Forecasts for RHIC Upgrades

As planned (Feb. 2008 NP budget briefing) / impact of 6 month CR scenario

Machine:

- **Stochastic cooling luminosity upgrade** — **Run 11**
  - CR: possible delay to Run 12
- **EBIS [U + U]** — **Run 11**
  - No CR impact

Forward detectors: **$W^{\pm}$ decay**

- **PHENIX Muon Trigger – full installation** — **Run 12(?)**
  - Partial implementation beginning Run 10 No CR impact
- **STAR Forward GEM Tracker** — **Run 11**
  - CR: probable delay of 1 year
  - Possible speed-up with non-DOE bridge funding

Particle and photon ID:

- **PHENIX Nose Cone Calorimeter** — **Run 13**
  - CR: delay to run 14
- **STAR Time of Flight** — **Run 10**
  - ~1/2 installed for Run 9 No CR impact

Vertex detectors:

- **PHENIX VTX** — **Run 11**
  - Possible technical delay. No CR impact
- **PHENIX FVTX** — **Run 12**
  - CR: delay to Run 13
- **STAR HFT** — **Run 13(?)**
  - CR: delay of 1 year

Summary

The detector upgrades are integral with the scientific planning for RHIC operations, and essential for the RHIC II physics program.

The total effort approximately equals that of the previous "small" RHIC experiments, BRAHMS and PHOBOS.

A detailed Mid-Term Plan, initiated in 2005, is an evolving road map.

The upgrades comprise a suite of multiple, small projects:
Require tighter, more central management to maintain schedules.

Details of individual detector upgrade projects given in Ed O'Brien's talk.
RCF status is presented in Michael Ernst's talk.